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3 ENERGY DISSIPATION CHARACTERISTICS IN TISSUE FOR IONIZING  
RADIATION IN SPACE 4

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The results of the study on galactic radiation hazards mentioned in the preceding Progress Reports (No. 15 and 16) are presented in two joint NASA-NAMI Research Reports:

NAMI-982, distributed in January 1967, A Note on the Galactic Radiation Exposure in Geomagnetically Unprotected Regions of Space;

NAMI-987, in print, to be distributed in Mid-March, Linear Energy Transfer Spectra and Dose Equivalents of Galactic Radiation Exposure in Space.

The analysis of the rem dose equivalents raises again the old question of how to treat the Bragg peaks of heavy nuclei terminating in tissue (so-called thindown hits). After the RBE Committee of the ICRP has stated clearly that for this part of galactic exposure "the concept of radiation dose itself fails" and consequently "the RBE concept is inapplicable," the approach of applying extremely high, but entirely arbitrary RBE factors to the thindown fraction of the galactic dose, as some Russian authors do, would not seem a very satisfactory solution. Particularly in view of the fact that galactic radiation represents a typical low-dose rate long-term exposure, it is unlikely that the "microbeam" effects of heavy nuclei thindown hits in the various tissues of the body can be fully assessed with one concise dosimetric unit whatever its definition. We feel that for a complete dosimetric analysis of galactic radiation this radiobiologically at present entirely unresolved fraction of the exposure should be carried as a separate item in the account of the various dose components listed with its physical characteristics rather than as a rem dose equivalent of any kind.

As far as the transition in shielding material is concerned, the "microbeam" fraction of the galactic exposure shows a basically different type of build-up as compared to ordinary high energy nucleons. In fact, the term "build-up" seems rather inappropriate and misleading because there is actually no production of secondaries in nuclear collisions involved, but the increase of thindown hits with increasing shield thickness is strictly due to the primary heavy nuclei themselves resulting from the particular spectral configuration of galactic radiation.

Work at the present time is directed toward a clarification of the quantitative relationships governing the transition of thindown hits as they would follow from the latest information on the primary galactic spectrum during solar maximum and minimum. Since thindown hits are contributed by the low energy end of the spectrum, the flux data on galactic radiation at solar minimum collected during 1964/65 are of special interest and can be expected to modify (i.e., upgrade sizeably) the older data on thindown hit frequencies which this author published in the mid-fifties when the configuration of the low energy end of the spectrum was only vaguely known by extrapolation.

The analysis is planned in three phases: 1). Re-check of the existing data on the Range/Energy and LET/Energy relationships for heavy nuclei in the low energy section below the Bragg peak with the objective of an accurate analysis of the transition curve for thindown hits. 2). Identification of the interval in the spectrum of the incident radiation contributing thindown hits for the purpose of a critical comparison of the spectral data of various experimenters and their respective accuracies in the spectral region in question. 3). Analysis of the transition curves themselves for representative types of heavy nuclei with special emphasis on shield thicknesses optimization for biological experimentation with heavy nuclei thindowns.

Except for data on the spectral configuration of the incident radiation at solar maximum and minimum, tabulations from earlier phases of Project R-75 cannot be utilized for this particular problem. Good data exist in the literature only to a limited degree and only on nuclei of the Z-class  $< 10$ . These latter data are not of much help since main interest from a radiobiological standpoint centers on nuclei at the upper end of the Z-scale (Ca,  $Z = 20$ ; Fe,  $Z = 26$ ). For these reasons, programming of the computations will be more time consuming. Results of the investigation should be available in four to six months.